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Fish Populations and Invertebrates in Some Headwaters of the Rivers Dee and Spey, 1983–1985

B R S Morrison and
R Harriman

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Fish Populations and Invertebrates in Some Headwaters of the Rivers Dee and Spey, 1983 — 1985

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Introduction

The Rivers Dee and Spey are two of the most important Atlantic salmon (*Salmo salar* L.) rivers in Scotland. For part of their length they flow over land which is of high agricultural value because of the calcareous nature of the soil and the levels of nutrients. In the upper reaches of both rivers, tributaries and lochs have formed in areas of slow-weathering bedrock where soils are well-leached and shallow, and where acid deposition may affect stream chemistry and fauna including the juvenile stages of salmonid fishes (Fig. 1) (Harriman and Morrison, 1981; Harriman *et al.*, 1987). From 1983 to 1985 as part of a joint sampling programme with the North East River Purification Board (NERPB) a study was made of the fish distribution in some of these sensitive upland areas. Samples of zooplankton and littoral benthos were collected from the lochs, together with water samples for chemical analysis. Water samples and invertebrates from the streams were collected and analysed by NERPB staff. In this report the results of the fish investigation of the lochs and streams and the invertebrate sampling in the lochs are presented and discussed in relation to water chemistry and other relevant environmental factors.

Materials and Methods

Site Selection

Initially, NERPB staff collected and analysed invertebrate and water samples from 88 streams. Twenty of these streams, comprising waters of different chemistry, were then selected for more detailed investigation. The fish populations of most of these streams were sampled as part of the wider investigation of fish distribution in the area. It was decided to limit sampling of the lochs to those waters most likely to be affected by acid deposition, because of the short time available for access to the area, generally May to July. Weather conditions in the early part of the year made travelling difficult and streams and lochs were often frozen. From August onward access is limited by sporting activities on the estates. The sampling sites are marked on Figures 2 and 3.

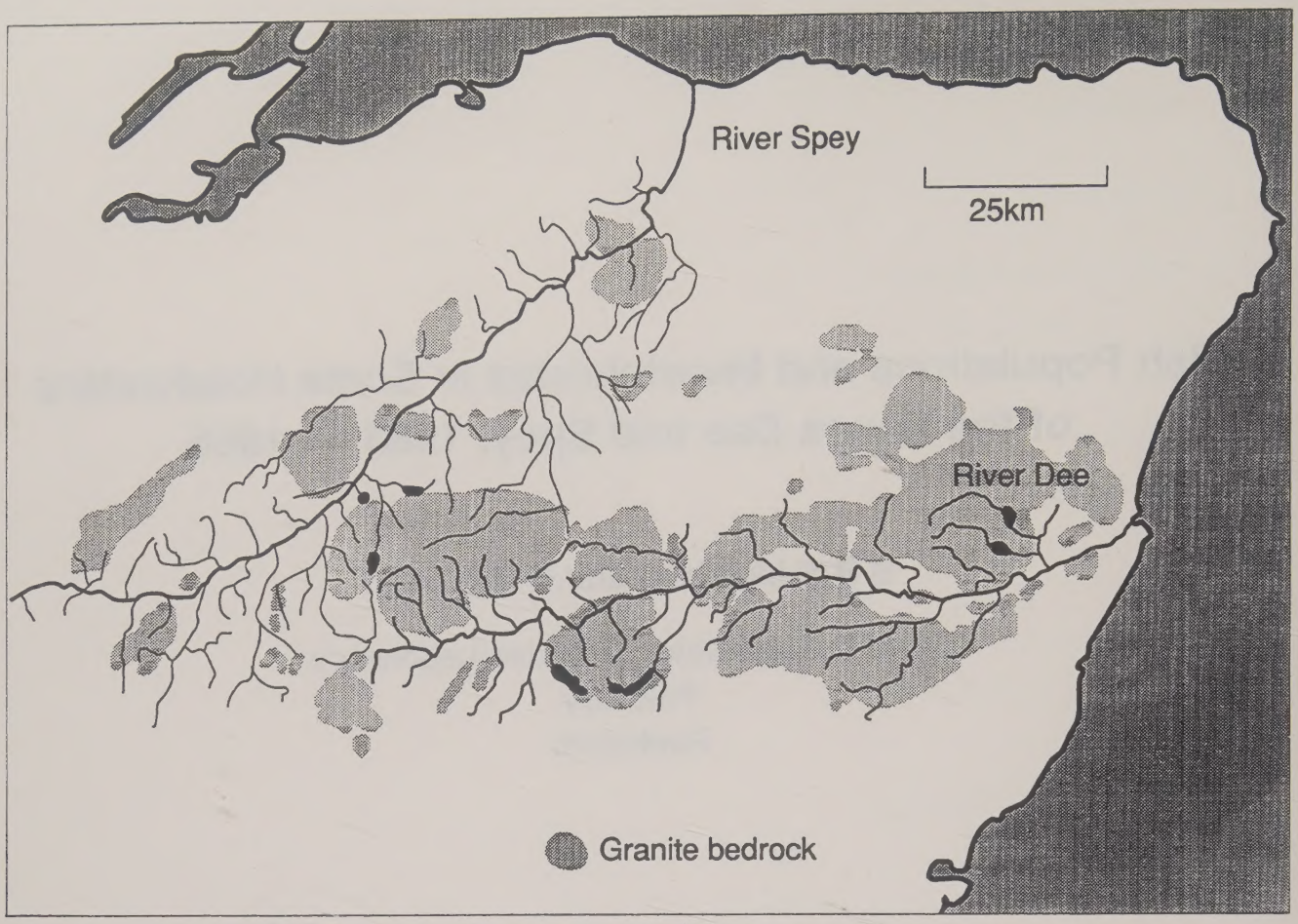

Figure 1. **The catchments of the River Dee and River Spey in relation to the distribution of slow - weathering granite bedrock.**

Sampling

Fish populations in the streams were sampled by electrofishing. Stop nets were set at either end of a section of stream which was fished three times in an upstream direction. Population estimates were calculated using the Zippin (1958) method. In most instances the stream was visited once only as the primary objective was to determine which species were present and which age classes were represented, but the opportunity arose to visit three streams twice which enabled a comparison to be made between catches from different years. Three streams were fished once only, without stop nets, and population estimates were not obtained for these. The lengths, and on most occasions the weights, of the fish were determined on site. Calculated weights based on these data were used for estimating biomass. The ages of 1+ and older fish were determined by scale reading. Because of the difficulty in distinguishing between salmon and trout (*Salmo trutta* L.) fry (0+) in the field in June and July, it was assumed that if older age groups of both species were present in the stream they would also be represented in the fry population. Accurate estimates of the sizes of fry populations were not always obtained because the nature of the substrate made difficult the capture of very small fish.

Fish in the lochs were sampled using a gang of three monofilament nylon nets each about 30 m long and 1.5 m deep, of mesh sizes 32, 44 and 50 mm stretched mesh. The nets were normally set across a bay and allowed to fish for 24 h. If no trout was caught the nets were set again for a further 24 h period. Scale samples were collected for age determination and when possible the stomach contents of 20 individuals from each loch were analysed using a points system similar to that of Hynes (1950) to estimate the bulk of each item.

Zooplankton samples from the lochs were collected from the open water by towing a net 1 m long with a 30 cm diameter opening and mesh size 250 nm for a distance of 50 m. The samples were preserved in 4% formalin and identified and counted in the laboratory. Qualitative samples of littoral benthos were obtained by kicking into the substrate and sweeping over the disturbed area with a handnet. The varied nature of the substrate in different lochs, from fine granite grit <2 mm diameter to rocks of 50 cm or more across, made it impossible to use a uniform sampling technique. The samples were preserved in 4% formalin and identified and counted in the laboratory.

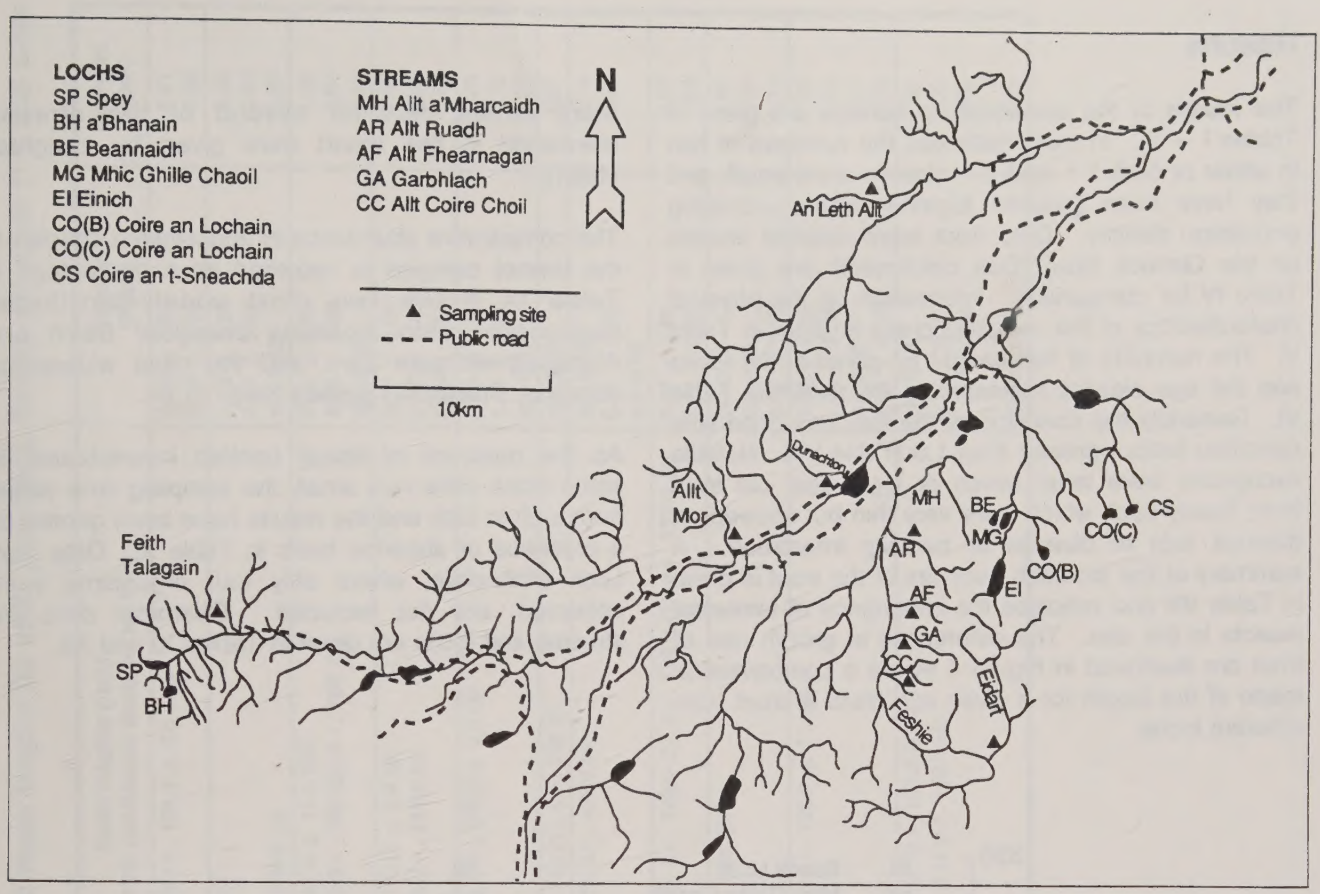

Figure 2. Sampling sites on lochs and streams in the catchment area of the River Spey.

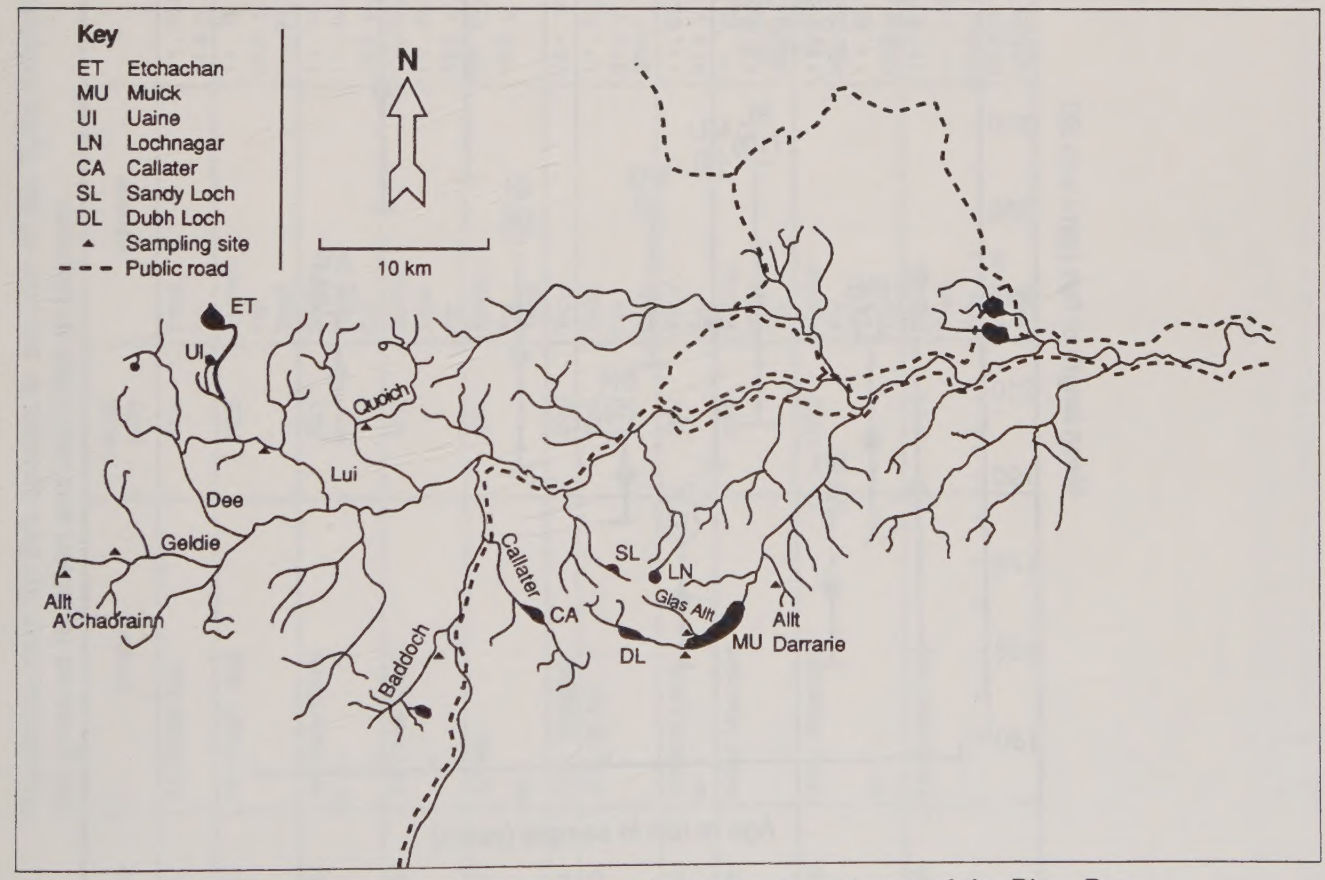

Figure 3. Sampling sites on lochs and streams in the catchment area of the River Dee.

Results

The results of the electrofishing surveys are given in Tables I — III. In most instances the numbers of fish in either or both 1+ and 2+ classes were small, and they have been grouped together when estimating population density. Data from more detailed studies on the Girnock Burn (Dee catchment) are given in Table IV for comparison. Information on the physical characteristics of the sampling areas is given in Table V. The numbers of fish caught by gillnet in the lochs and the age classes represented are shown in Table VI. Generally the condition of the fish was good with condition factors greater than 1.0 (Table VII). Notable exceptions were large seven or eight year old trout from Sandy Loch which were very thin but showed no obvious sign of disease or parasite infestation. A summary of the stomach contents of the trout is given in Table VIII and indicates the importance of terrestrial insects in the diet. The differences in growth rate of trout are illustrated in Figure 4 where a comparison is made of the length for a given age class of trout from different lochs.

More recent data for several of the streams mentioned in this report were given by Laughton (1991).

The comparative abundance of zooplankton species in the townet samples is recorded as a percentage in Table IX. The two most widely-distributed cladocerans were *Bosmina coregoni* Baird and *Alonopsis elongata* Sars, and the most widespread copepod, *Diaptomus gracilis* Sars.

As the numbers of littoral benthic invertebrates in some lochs were very small, the sampling time varied from loch to loch and the results have been quoted on a presence or absence basis in Table X. Data from Loch Etchachan, where only four organisms were collected, are not included. Chemical data for streams and lochs are given in Tables XI and XII.

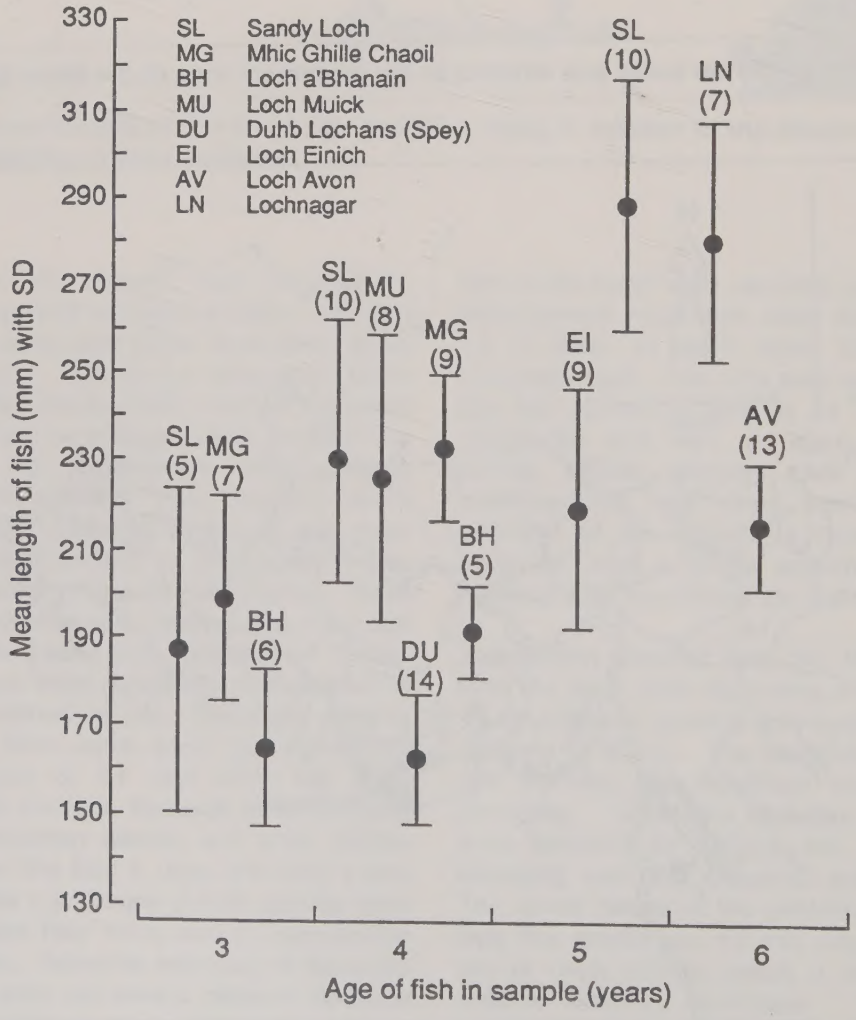

Figure 4. The mean length and standard deviation of trout of different age classes from lochs in the River Dee and River Spey catchments. Number of fish examined is given in brackets.

Table I: Population data for fish species in streams of the Spey catchment, with mean lengths for each year class, density estimates (1+ and older fish grouped together) and estimates of biomass

Date	Stream	Area (m^2)	Species	Mean lengths (mm) (with 95% confidence limits of >5 fish)	Density (N/m^2)	Biomass (g/m^2)
28.06.84	Allt Ruadh (up)	71.2	Trout	1+, 74.8 ± 5.1 (7): 2+, 104.3 ± 8.8 (12)	0.29 ± 0.06	3.21
			Fry	34.3 ± 3.8 (9)	0.13 ± 0.02	0.08
06.07.84	Allt Ruadh (mid)	60.5	Salmon	1+, 70.7 ± 9.1 (10)	1.19 ± 0.28	6.24
			Fry	34.0 ± 2.6 (47)	1.07 ± 0.48	0.46
			Trout	1+, 79.0 (1): 2+, 105.0 (1)	min 0.03	0.27
29.06.84	Allt Coire Chaoil	35.1	Salmon	1+, 74.0 (1): 2+, 97.3 ± 11.5 (12)	0.41 ± 0.13	4.35
			Trout	1+, 74.0 ± 3.5 (5): 3+, 145 (2): 4+, 198 (1)	0.25 ± 0.09	6.00
			Fry	33.9 ± 2.4 (9)	min 0.25	0.12
03.07.85	Allt Coire Chaoil	57.3	Salmon	1+, 81.5 (4): 2+, 117.0 ± 6.4 (5)	0.17 ± 0.04	2.04
			Trout	1+, 72.3 ± 5.4 (6): 2+, 115.0 (1)	0.12 ± <0.01	0.64
			Fry	33.4 ± 2.5 (21)	0.38 ± 0.05	0.17
04.08.84	Allt Mor	67.6	Salmon	1+, 91.2 ± 3.6 (5): 2+, 122.6 ± 7.3 (5)	0.15 ± <0.01	2.40
			Fry	48.9 ± 3.3 (79)	1.24 ± 0.11	1.75
			Trout		min 0.01	2.32
14.08.84	Feith Talagainn	59.6	Trout	?2+, 106 (1): 3+, 148 (1): 4+, 198 (2)	min 0.07	3.41
02.07.85	An Leth Allt	62.6	Trout	1+, 70.0 ± 10.4 (8): 2+, 101.0 (3)	min 0.18	1.15
			Fry	31.4 ± 2.7 (8)	0.14 ± 0.05	0.08
			Eel	200 (1)	min 0.02	
04.07.85	Wells of Lecht	38.4	Trout	1+, 82.6 ± 10.1 (3): 2+, 123.0 (2): 3+, 170.0 (1): 4+, 252.0 (1)	0.33 ± 0.08	4.67
			Fry	31.0 ± 5.0 (130)	4.84 ± 0.35	1.60
10.07.85	Allt a' Mharcaidh	68.3	Salmon	1+, 82.0 (3): 2+, 112.5 (2)	min 0.07	0.94
			Trout	1+, 98.0 (2)	min 0.03	0.37
			Fry	38.5 ± 5.3 (97)	2.46 ± 1.40	1.71
10.10.85	Allt a' Mharcaidh	186.2	Salmon	1+, 90.6 ± 4.9 (8): 2+, 122.0 ± 7.1 (5)	0.08 ± 0.03	1.00
			Fry	48.0 ± 2.9 (44)	0.26 ± 0.04	0.35
			Trout	1+, 80.8 (4)	min 0.03	0.17
			Fry	56.9 ± 4.8 (71)	0.39 ± 0.02	0.78
09.08.85	Dunachton Burn	136.0	Salmon	1+, 99.1 ± 10.1 (19): 2+, 121.5 (2)	min 0.15	1.80
			Trout	1+, 116.5 ± 12.1 (14): 2+, 163.3 (3)	0.17 ± 0.01	3.53
			Fry	51.6 ± 3.6 (9)	0.59 ± 0.06	0.89
			Lamprey	85.5 ± 18.9 (11)		
			Eels	365 (2)	min 0.01	0.28

Table II: Population data for fish species in streams of the Dee catchment, with mean lengths for each year class, density estimates (1+ and older fish grouped together) and estimates of biomass

Date	Stream	Area (m^2)	Species	Mean lengths (mm) (with 95% confidence limits of >5 fish)	Density (N/m^2)	Biomass (g/m^2)
13.06.84	Lui Beag	323.4	Trout	1+, 54 (2): 2+, 101.67 (3): 3+, 133.40 ± 11.70 (5): 4+, 168.0 (1)	0.05 ± 0.05	1.06
13.06.84	Quoich	152.4	Salmon	1+, 4.49 (2)	0.01 ± 0.01	0.04
14.06.84	Geldie	277.6	Salmon Fry	1+, 66.23 ± 12.61 (29): 2+, 92.33 (3) 28.67 ± 1.58 (9)	0.16 ± 0.09 0.03 ± 0.01	0.69 <0.01
21.06.84	Callater	112.1	Salmon Fry Eels	1+, 61.9 ± 14.8 (18): 2+, 101.0 (4) 30.5 (4) 192.6 ± 23.1 (17)	0.35 ± 0.10 0.04 ± 0.01 0.21 ± 0.15	1.36 0.01 2.12
12.07.85	Callater	95.2	Salmon Fry Eels	1+, 77.3 ± 12.9 (4): 2+, 107.5 (2) 34.7 ± 2.7 (6) 228.6 ± 44.6 (5)	0.08 ± 0.08 0.07 ± 0.03 min 0.05	0.71 0.04 1.08
27.06.84	Baddoch	71.6	Salmon Trout Fry Eels	1+, 66.9 ± 4.5 (17): 2+, 105.1 ± 9.8 (12): 3+, 120.0 (1) 2+, 142 (1): 3+, 155 (1): 4+, 176 (1) 31.87 ± 2.58 (30) (6) not measured	0.43 ± 0.04 min 0.04 min 0.41 min 0.08	3.43 1.83 0.22
12.07.85	Baddoch	118.7	Salmon Fry Eels	1+, 67.4 ± 4.8 (28): 2+, 101.3 ± 5.3 (2) 33.5 ± 2.6 (35) 241.9 ± 31.6 (7)	0.55 ± 0.38 min 0.29 min 0.05	3.64 0.13 1.12
12.07.84	Allt Darrarie	58.3	Salmon Fry Trout Fry	1+, 85.9 ± 7.9 (14): 2+, 121.5 (2) 46.4 ± 3.0 (19) 1+, 89.4 ± 9.6 (11) (1) not measured	0.30 ± 0.07 0.36 ± 0.09 0.26 ± 0.26 min 0.02	2.97 0.48 2.29
15.07.85	Dubh Loch outflow	37.5	Trout Fry	1+, 49.0 (2) 24.5 (2)	min 0.05 min 0.05	0.06 <0.01

Table III: Streams fished once only to determine the species present (ie, no estimate made of population density)

Date	Stream	Area (m^2)	Species	Mean lengths (mm) with 95% confidence limits of >5 fish
28.06.84	Allt Garbhlach	27.6	Salmon Trout Fry	1+, 63.8 ± 8.3 (6): 2+, 92.3 (3) 1+, 72.0 (1) 30.7 ± 2.0 (9)
28.06.84	Allt Fhearnagan*	32.2	Salmon Fry	1+, 63.1 ± 12.5 (10): 2+, 87.5 (2) 0.7 ± 3.6 (7)
19.06.84	Allt Ruadh (lower)	42.2	Salmon Trout Fry	1+, 64.0 ± 5.3 (6): 2+, 94.5 ± 4.8 (4) 2+, 157 (1) 32.2 ± 4.3 (5)
05.07.84	Allt a' Chaorainn	38.9	Salmon	1+, 79.0 ± 6.5 (5): 2+, 95.0 (4)

*Trout were found further up stream, near the foot of the waterfall.

Table IV: Data from electrofishing survey of the juvenile salmon population in the River Girnock (Dee catchment)

Date	Area fished (m^2)	Age class	No. of fish caught	Mean length (mm)	Density (N/m^2)	Biomass (g/m^2)
July 1983	717	0+	128	36.6	0.18	0.11
		1+	76	79.1	0.11	0.64
		2+	40	101.7	0.06	0.73
		3+	7	114.7	0.01	0.17
July 1984	717	0+	97	44.6	0.14	0.15
		1+	188	78.3	0.26	1.46
		2+	53	103.8	0.07	0.90
		3+	4	117.0	0.01	0.18

Table V: Physical characteristics of the sampling area in each stream

Date	Stream	Width (m)	Area (m^2)	Depth (cm)	% Stream bed material (cm)					Remarks
					Sand	0-2	3-20	21-50	>50	
13.06.84	Lui Beag	7.7	323.4	19.3 ± 6·7			50	50		
13.06.84	Quoich	9.8	152.4	28.5 ± 12.4	10		30	60		Moss < 5%
14.06.84	Geldie	12.7	277.6	11.5 ± 6.2			50	45	5	Filamentous algae throughout
21.06.84	Callater	11.8	112.1	20.6 ± 6.7			40	40	10	10% bedrock
12.07.84	Dubh Loch outflow	4.6	58.4	23.1 ± 6.9			60	20	20	Moss 30%
27.06.84	Baddoch	10.2	71.6	13.7 ± 4.3			45	45	10	Algae < 5%
12.07.84	Allt Darrarie	6.1	58.3	13.4 ± 4.8	< 5 (silt)		20	60	20	
12.06.84	Glas Allt	5.0	37.5	20.6 ± 9.3		5	60	10		20% bedrock
10.07.85	Allt a'Mharcaidh	3.7	68.3	not measured		20	50	20	10	
28.06.84	Allt Ruadh (up)	5.6	71.2	15.7 ± 7.2	20	10	60	10		10% moss 30% algae
06.07.84	Allt Ruadh (mid)	6.4	60.5	10.5 ± 4.4		50	45	5		
29.06.84	Allt Coire Chaoil	2.7	35.1	14.1 ± 6.0		40	50	5		
03.07.85	Allt Coire Chaoil	3.6	57.3	not measured		30	50	20		
14.08.84	Feith Talagainn	4.8	59.6	16.0 ± 6.6			60	20		20% bedrock
02.07.85	An Leth Allt	2.4	62.6	not measured			25	70	5	Dense growth of filamentous algae throughout. Some *Fontinalis*
04.07.85	Wells of Lecht	2.6	38.4	not measured		5	60	20	15	
09.08.85	Dunachton Burn		136.0							
06.07.84	Allt a'Chaorainn	3.5	38.9	8.1 ± 4.1	10		60	20		10% bedrock
29.06.84	Allt Ruadh (low)	3.7	42.2	14.8 ± 7.9			20	70	< 1	
28.06.84	Allt Garbhlach	2.8	27.6	15.0 ± 4.8			60	40		Moss 5% *Lemanea* (algae) 5%
28.06.84	Allt Fheamagan	2.3	32.2	12.4 ± 5.1			40	60	1	

Table VI: Area and location of lochs in the catchments of the Rivers Dee and Spey with number of fish caught

Date	Loch	Area (ha)	Grid reference	No. of trout caught	Age classes represented
17.06.83	Lochnagar	8.5	NO252860	13	5, 6, 7
02.06.83	Sandy	3.5	NO228865	33	3, 4, 5, 6, 7, 8
09.06.83	Dubh Loch (Dee)	23.0	NO243827	32	3, 4, 6, ?, 8
09.06.83	Muick	222.0	NO300835	47	2, 3, 4, 5, 7
26.05.83	Callater	27.0	NO180843	1	6
14.06.84	Etchachan	23.0	NJ007003	0	
14.06.84	Uaine (Ben macDui)	3.2	NO001981	0	
08.08.84	Stuirteag		NN942957	0	
08.09.83	Dubh Lochans (Spey)	2.0	NJ036023	56	3, 4, 5
01.09.83	Coire an Lochain (C)	0.75	NH982029	0	
02.09.83	Coire an t-Sneachda	0.3	NH995032	0	
30.08.83	Einich	75.0	NN915990	37	3, 4, 5, 6, 7, 8
30.08.83	Coire an Lochain (B)	7.75	NH943005	0	
30.08.83	Beannaidh	0.75	NH911027	16	1, 3, 4, 5
30.08.83	Mhic Ghille Chaoil	7.3	NH921025	84	3, 4, 5
26.08.83	Avon	41.25	NJ015025	56	2, 3, 4, 5, 6, 7
08.08.84	nan Cnapan	2.7	NN917961	0	
11.07.84	Spey	5.0	NN421938	67	1, 2, 3, 4
11.07.84	a' Bhanain	7.0	NN430922	180	2, 3, 4

Table VII: Condition factors of fish in streams and lochs of the upper reaches of the Rivers Dee and Spey

Date	Water	Species	No. in sample	Condition factor (± standard deviation)
28.06.84	Allt Ruadh (up)	Trout	19	1.138 ± 0.064
06.07.84	Allt Ruadh (mid)	Salmon	13	1.128 ± 0.151
29.06.84	Allt Coire Chaoil	Trout	7	1.128 ± 0.040
29.06.84	Allt Coire Chaoil	Salmon	13	1.138 ± 0.070
14.08.84	Allt Mor	Trout	7	1.188 ± 0.079
14.08.84	Allt Mor	Salmon	10	1.247 ± 0.148
13.06.84	Lui Beag	Trout	11	1.196 ± 0.163
14.06.84	Upper Geldie	Salmon	31	1.162 ± 0.124
27.06.84	Baddoch Burn	Salmon	30	1.137 ± 0.083
12.07.85	Baddoch Burn	Salmon	44	1.132 ± 0.117
12.07.85	Callter Burn	Salmon	6	1.188 ± 0.054
12.07.84	Allt Darrarie	Trout	16	1.259 ± 0.125
17.06.83	Lochnagar	Trout	13	1.011 ± 0.128
02.06.83	Sandy Loch	Trout	33	0.994 ± 0.084
09.06.83	Dubh Loch (Dee)	Trout	32	1.119 ± 0.102
09.06.83	Loch Muick	Trout	47	1.035 ± 0.078
08.09.83	Dubh Lochans (Spey)	Trout	56	1.075 ± 0.119
30.08.83	Loch Einich	Trout	36	0.985 ± 0.101
30.08.83	Loch Beannaidh	Trout	16	1.098 ± 0.099
30.08.83	L Mhic Ghille Chaoil	Trout	31	1.151 ± 0.079
26.08.83	Loch Avon	Trout	56	1.119 ± 0.100
11.07.84	Loch Spey	Trout	40	1.143 ± 0.103
11.07.84	Loch a' Bhanain	Trout	40	1.104 ± 0.132

Table VIII: Stomach contents of trout from lochs in the catchments of the Rivers Dee and Spey. Samples collected June to September 1983/1984. Percentage abundance of food items by volume

	June 1983			August-September 1983						July 1984	
	LN	DL	SL	MU	EI	BE	MG	DU	AV	SP	BH
Ephemeroptera (mayflies)			1			8		2			
Plecoptera (stoneflies)	8	2									
Hemiptera (water bugs)											
Corixidae			1								
Trichoptera (caddis)											
Limnephilidae			54		2						13
Polycentropidae		1	2	2	17	3	44	16			
Phryganea sp.			10							3	13
Unident.								1		2	5
Coleoptera (beetles)											
Dytiscidae		3	8			7	16				
Diptera (flies)											
Chironomidae	6	5	5	7						5	36
Megaloptera (alder flies)	86	42	20				8		6		
Hydracarina (mites)									2		
Mollusca (snails etc)				3						1	2
Crustacea											
Cyclops spp.				5							
Eurycercus lamellatus						27				16	3
Terrestrial insects		47	1	80	81	63	32	60	93	70	25
Mammalia											
Sorex sp.								15			
Aquatic plants											3
No. in sample	13	20	30	20	20	10	20	20	10	19	20
Empty stomachs	1	2	2	4	7	4	13	4	1	5	10

KEY

LN - Lochnagar
DL - Dubh Loch
SL - Sandy Loch
MU - Loch Muick
EI - L Einich
BE - L Beannaidh
MG - Mhic Ghille Chaoil
DU - Dubh Lochans (Spey)
AV - Loch Avon
SP - Loch Spey
BH - Loch a'Bhanain

Table IX: Percentage abundance of zooplankton in samples from lochs in catchments of the Rivers Dee and Spey

	CN	ST	EI	BE	MG	CO (B)	AV	DU	CO (C)	CS	LN	SL	CA	DL	MU	BH	SP
Cladocera																	
Sididae																	
Diaphanosoma brachyurum				82												11	
Holopedidae																	
Holopedium gibberum			1								79			58			
Daphniidae																	
Ceriodaphnia quadrangula				85													
Daphnia hyalina	1		1														
Bosminidae																	
Bosmina coregoni	90	95	73	9	2	20	12	92	89	53	12	97		41	5	97	
Chydoridae																	
Acroperus harpae																	
Alonopsis elongata	1		22		3	76	87	7	6	2	1	1		1	2		
Eurycercus lamellatus					1								2				
Chydorus sp.						2				37		1					
Peracantha truncata								1									
Rhynchotalona rostrata	?																
Polyphemidae																	
Polyphemus pediculus	1										6	1			93	2	
Copepoda																	
Diaptomidae																	
Diaptomus gracilis	8	5	1	6	12			2			1	1	21		1		
Cyclopidae																	
Cyclops spp.	1		2			2			4	9	1	1	77	1			
No. of animals in sample	2,320	2,830	500	2,310	1,020	250	1,200	334	47	59	949	3,855	48	904	721	2,545	

KEY CO (B) - Coire an Lochain (Braeriach) CN - nan Cnapan ST - Stuirteag EI - Einich BE - Beannaidh
CO (C) - Coire an Lochain (Cairngorm) AV - Avon DU - Dubh Lochans (Spey) LN - Lochnagar SL - Sandy Loch
CS - Coire an t-Sneachda CA - Callater MU - Muick BH - Loch a' Bhanain SP - Loch Spey
MG - Mhic Ghille Chaoil DL - Dubh Loch (Dee)

Table X: Benthic invertebrates collected from the littoral zone of lochs in catchments of the Rivers Dee and Spey (+ = present)

	ST	EI	BE	MG	CO (B)	AV	DU	CO (C)	CS	LN	SL	CA	DL	MU	BH	SP
Nematoda																
Mollusca															+	
Limnaea peregra		+										+		+	+	
Ancylus fluviatilis												+				
Pisidium spp.		+										+			+	
Oligochaeta																
Stylaria lacustris															+	
Chaetogaster sp.		+														
Naididae															+	
Tubificidae		+									+		+			
Enchytraeidae		+								+			+			
Lumbriculus				+			+	+						+		
Stylodrilus heringianus				+				+								
Eiseniella tetraedra										+		+				
Hirudinea																
Helobdella stagnalis												+				
Crustacea																
Gammarus lacustris												+				
Ephemeroptera																
Siphlonurus lacustris									+		+	+				
Ameletus inopinatus					+											
Procloeon bifidum														+		
Leptophlebia vespertina												+				
Plecoptera																
Nemoura avicularis		+	+													
Leuctra nigra		+														
Leuctra fusca																
Diura bicaudata		+														
Isoperla grammatica																
Chloroperla torrentium						+						+				

Table X (continued)

	ST	EI	BE	MG	CO (B)	AV	DU	CO (C)	CS	LN	SL	CA	DL	MU	BH	SP
Coleoptera																
Hydroporus palustris																
Hygrotus novemlineatus												+				
Deronectes depressus							+									
Deronectes assimilis												+				
Deronectes griseostriatus	+										+		+			
Oreodytes rivalis		+							+		+					
Agabus bipustulatus	+				+			+								
Agabus chalconatus	+															
Limnius volckmari														+		
Oulimnius tuberculatus											+	+		+		
Megaloptera																
Sialis lutaria											+					
Trichoptera																
Plectrocnemia conspersa							+			+			+			
Polycentropus kingi															+	
Polycentropus flavomaculatus		+	+	+							+	+		+	+	+
Holocentropus dubius			+													
Holocentropus picicornis														+		
Cyrnus trimaculatus															+	
Phryganea sp.	+			+												
Limnephilidae		+	+			+			+					+		
Chaetopteryx villosa										+						
Mystacides azurea																+
Triaenodes bicolor																+
Sericostoma personata															+	
Diptera																
Dicranota sp.	+				+											
Tipulidae	+					+	+									
Chironomidae		+	+	+	+			+		+	+	+	+	+	+	+

KEY

ST	-	Stuirteag	AV	-	Avon	SL	-	Sandy Loch
EI	-	Einich	DU	-	Dubh Lochans (Spey)	CA	-	Callater
BE	-	Beannaidh	CO(C)	-	Coire an Lochain (Cairngorm)	DL	-	Dubh Loch (Dee)
MG	-	Mhic Ghille Chaoil	CS	-	Coire an t-Sneachda	MU	-	Loch Muick
CO(B)	-	Coire an Lochain (Braeriach)	LN	-	Lochnagar	BH	-	Loch a'Bhanain
SP	-	Loch Spey						

Table XI

Chemical analysis of water samples from lochs in the headwaters of the catchments of the Rivers Dee and Spey. (Values quoted in µeq l^{-1} except for Al and Fe (in µg l^{-1}) and pH.)

Loch	No of samples	pH	Alk	Cond.	Na	K	Ca	Mg	Cl	SO_4	NO_3	Al-TM	Al-L	Fe-TS
Lochnagar	2	4.96	0	23.0	82.0	6.0	40.0	27.0	86.0	93.0	19.5			
Sandy	2	5.47	17.0	23.5	69.5	7.0	33.0	24.0	92.0	102.0	17.5			
Dubh Loch (Dee)	3	5.14	7.3	18.0	57.0	5.3	28.0	16.7	54.7	67.0	10.3	111	111	
Muick	3	5.44	19.3	24.7	74.7	8.0	41.7	29.3	76.0	88.3	10.3			
Callater	3	6.72	82.0	26.7	76.0	9.7	86.0	35.7	82.7	84.3	10.0			
Etchachan	2	5.04	0.5	16.9	68.5	5.0	18.5	16.5	56.0	65.5	12.5	53	53	
Uaine (Ben Macdui)	1	5.35	12	18	82	5	36	18	84	44	16			
Stuirteag	1	5.35	11	48	72	3	20	13	72	43	1			
Coire an Lochain (C)	2	5.64	15.0	10.0	39.5	7.0	14.5	9.0	28.5	26.5	7.5	2	2	30
Coire an t-Sneachda	3	6.08	20.7	16.5	59.0	4.0	40.7	13.3	39.3	62.3	7.7	8	8	25
Einich	3	6.21	27.5	21.3	77.5	6.3	58.0	19.8	76.0	68.5	9.8	19	9	41
Coire an Lochain (B)	3	5.22	11.0	16.9	58.3	6.0	19.3	19.0	57.3	53.3	16.0	30	30	31
Beannaidh	1	5.96	22	25	98	8	52	31	116	90	2	37	16	39
Mhic Ghille Chaoil	2	4.54	0	31.5	83	7	26	26	88	116	6.5	76	37	207
Avon	3	5.17	14.0	16.1	55.3	3.3	20.0	14.7	57.3	66.3	4.0	35	35	22
nan Cnapan	3	5.92	23.0	32.5	61.7	4.0	42.7	13.3	57.0	59.3	3.7			
Spey	1	7.63	362	60	217	18	247	117	152	89	11			
a'Bhanain	1	7.20	13	32	146	13	99	59	124	59	5	5		

(B) - Braeriach
Al-TM = Total monomeric aluminium
Fe-TS = Total soluble iron

(C) - Cairngorm
Al-L = Labile aluminium
Cond. = Conductivity (in micro Siemens/cm)

Table XII

Chemical analysis of water samples from streams in the catchments of the Rivers Dee and Spey (preliminary data). (Values in µeq l^{-1} except for pH and conductivity. When n > 1 the mean is given)

Stream	No of samples	pH	Alk	Cond.	Na	K	Ca	Mg	Cl	SO_4	NO_3
Lui Beag	5	5.88	25.6	23	91.4	7.2	49.2	22.8	95	71.3	6.9
Quoich	2	6.40	38.0	20	96.5	7.0	58.0	25.0	90	94.0	6.0
Geldie	3	6.39	118.5	35.5	87	7	124.7	35.3	84	96	8
Callater	1	7.64	306	40	93	13	289	65	72	68	12
Baddoch	1	8.03	616	71	110	22	525	185	84	81	3
Allt Darrarie	1	7.84	474	61	207	25	275	166	100	58	14
Dubh Loch (out)	*	*	*	*	*	*	*	*	*	*	*
Glas Allt**	1	6.40	100	24	163	6	45	36	85	71	
Allt a'Chaorainn	1	7.30	148	28	126	7	95	43	92	49	3
Allt Mor**	1	6.85	190	52	218	21	151	109	113	56	
Feith Talagainn**	1	6.80	340	44	186	17	139	76	113	65	
An Leth Allt**	1	7.05	740	89	317	22	326	205	197	71	
Wells of Lecht**	1	7.55	860	105	177	14	675	219	141	85	
Dunachton**	1	7.35	840	110	293	31	605	204	169	60	
Allt a'Mharcaidh	4	6.29	43.3	26	127.3	7.3	49.3	34.0	122	69	6.0
Allt Ruadh**	1	6.50	140	31	181	8	69	38	113	54	
Allt Fhearnagan	1	6.52	68	21	125	6	44	23	84	50	2.5
Allt Garbhlach	1	7.09	124	29	110	7	127	39	96	63	5
Allt Coire Chaoil	1	7.36	190	33	129	9	122	52	92	53	3.5
Eidart	1	7.03	72	20	94	7	57	25	80	46	2.5

*Not recorded
**Data from initial survey by North East River Purification Board, August 1983

Discussion

Stream Survey

Many of the streams forming the headwaters of the Dee and Spey have waterfalls which form barriers to upstream-migrating salmon, sea trout and eels. Such falls are present on the Lui and the Quoich (Dee catchment), about 1 km upstream from the main river, and in the Spey catchment there are falls on five of the six tributaries of the River Feshie. With the exception of the River Eidart, salmon were found at the base of these obstructions. The presence of salmon parr in Allt a' Chaorainn, a tributary of the River Geldie about 110 km from the mouth of the Dee, demonstrates that in the absence of obstructions salmon will penetrate small tributaries close to the source of a river. Gardiner and Egglishaw (1986) also noted that salmon were found near Loch Spey, a distance of about 140 km from the mouth of that river and close to the source. The occurrence of 0+, 1+ and 2+ salmon at all the salmon sites investigated except the River Quoich, and the Allt Ruadh (where only the 2+ age class was missing), indicates that conditions generally in the area are favourable to salmon development.

The Allt Ruadh was surveyed along with other tributaries of the River Spey by Laughton in 1990 who found lower numbers of salmon at the site he sampled but higher numbers of trout than were found at the middle site during the present survey (Laughton, 1991). The only other stream common to both surveys of the Spey catchment for which population density data are available is the Dunachton Burn. Laughton records lower densities of salmon and trout and makes no mention of lampreys or eels.

Data on population densities and biomass in the streams sampled during this survey were in most cases comparable with the data available for other streams (eg Egglishaw and Shackley, 1977; Laughton, 1991; Mills, 1985), and with the results of more detailed studies on another tributary of the River Dee, the Girnock Burn (Table IV) (D Hay, pers. comm.).

The absence of trout from the upper reaches of the Geldie Burn and its tributary Allt a' Chaorainn, may be due to the riffle-like character of these streams which is more typical of a salmon habitat. The stream bed at these sites is relatively uniform with no well-defined pools (Table V). A comparable situation was found during a survey of the River Cree (Kirkcudbright) where a tributary near the source was found to contain salmon parr and minnows (*Phoxinus phoxinus* L.) but no trout. Several streams, namely Lui Beag, Glas Allt, Feith Talagainn, Wells of Lecht and An Leth Allt, contained only trout but all had obstructions in their lower reaches or further down stream in the main river.

The River Eidart, a tributary of the River Feshie, is of particular interest because no fish was found above the waterfall near its mouth, although a few trout were caught by electrofishing a short distance down stream from the falls. It is possible that these fish could have entered from the Feshie and that there are times when the water chemistry of the Eidart is unsuitable for trout. The pH recorded for the time of the visit was 7.03 but the alkalinity was low at 72 $\mu eq\ l^{-1}$ (3.6 $mg\ l^{-1}$ as calcium carbonate) indicating low buffering capacity. Nevertheless, lower readings were obtained from other streams with good fish populations (Table XI). It was a general characteristic of the streams which were sampled that pH levels were usually greater than 6.0, but alkalinity readings low. The relatively high pH levels would limit the solubility of the aluminium compounds which are toxic to fish. Calcium levels were low, in most cases less than 100 $\mu eq\ l^{-1}$ (2 $mg\ l^{-1}$). The most obvious exceptions to this generalisation are the Baddoch, Callater, An Leth Allt and Allt Darrarie, the first three of which were the only streams found to contain eels (*Anguilla anguilla* L.). All had relatively high calcium levels.

The higher calcium levels in the Baddoch and the Callater were also noted by Shackley and Donaghy (1992) during a survey of these streams in 1988 and 1989. They sampled at several locations and in contrast to the findings from this survey found 0+ salmon in the Baddoch, at densities of 0.8 to 1.3 m^{-2}. Most of their results are recorded as biomass and their values for the Baddoch, up to 5 $g\ m^{-2}$, are comparable with those for the present survey. The values for most of their Ballater sites were slightly greater but one was much less. Differences in the character of the stream bed could account for these and for differences in the figures for the Geldie, 0.7 $g\ m^{-2}$ in this survey, and about 1.5 $g\ m^{-2}$ in 1988.

Loch Survey — Trout

Trout were caught in 12 of the 19 lochs sampled. The number of trout sampled was in no way related to the surface area of the loch. The same number of fish (56) was caught in Loch Avon (surface area 41.25 ha) as in the neighbouring Dubh Lochans (2 ha), and nets set in Loch a' Bhanain (7 ha) produced 180 trout. It is not known whether this is a reflection of the densities of the two populations or the result of a chance encounter with the nets. A few lochs with trout (Beannaidh, Mhic Ghille Chaoil, Lochnagar and a' Bhanain) have no inflow stream, and the outflow from at least the first two dries out periodically. It seems likely therefore that trout in these lochs spawn in the stony littoral zone. If it is assumed that in general a high proportion of juvenile trout spends two years in the stream, the appearance of 3+ fish as the youngest age group in nets set in lochs with continuously running inflows is to be expected. The capture of 1+ fish would depend on whether they had grown fast enough to be of sufficient size to be caught. This was probably the case in Loch Beannaidh but not in Mhic Ghille Chaoil. With the exception of Lochnagar and Loch Callater (where only one trout was caught), fish of age classes 3+ and

4 + were present in all the trout lochs. Information on trout catches from lochs where fishing is practised regularly shows that these age classes are the ones most frequently caught (SOAFD unpublished data). In the lochs sampled in the present study, angling pressure is light and older fish were not uncommon in the nets (Table VI). The absence of fish younger than 5 + in Lochnagar may indicate spawning failure in recent years or mortalities at a later stage among the earlier year classes. If fish normally spawn in the littoral zone an extended period of ice cover might damage eggs or fry. The absence of year classes has, however, been noticed in water subject to acid episodes (Harvey, 1982) and the chemistry of Lochnagar (Table XI) suggests that the effects of acidity might explain the findings there. Against this argument are the data from Loch Mhic Ghille Chaoil where 84 trout of three, four and five years old were caught and where a pH level of 4.54 was recorded; this is a level believed to be close to the lower limit for trout (Alabaster and Lloyd, 1980). Similar levels have been recorded at Loch Grannoch in Kirkcudbright where there is evidence of a decline in trout stocks during the past 40 years (Harriman *et al.*, 1987).

Generally, the pH of the lochs was lower than that of the streams, most waters being between pH 5.0 and 6.0. Readings from Lochs Einich and Callater were usually above 6.0. The levels of labile aluminium were low despite the reduced pH being close to the value for maximum solubility of the toxic aluminium compounds (about pH 5.0), and levels of the other ions were comparable to those found in the streams.

Of the seven lochs where no trout was caught, all are in exposed sites at heights of 900 to over 1,000 m and may be subject to long-term ice cover which could limit spawning or hatching success. Ice was present in Lochan Uaine during the visit on 30 August 1983. Only Loch Etchachan has a well-defined but very steep inflow and only Loch nan Cnapan and Loch Stuirteag have outflows which flow over land of a shallow gradient. These two lochs have a littoral zone with peaty soil and areas of small gravel, unlike the others, where boulders and granite grit predominate.

The growth rates of the trout vary from loch to loch but there is a wide variation in length for a given age in each loch (Fig. 4). Growth rate depends on factors such as population density, which is influenced by recruitment and predation (including angling), temperature and food availability. It is not possible from such a limited survey to say which factors are most important although temperature is likely to be a key one because it determines the length of time available for active feeding. Angling pressure and predation are likely to be minor influences.

Analysis of the stomach contents of the trout revealed a high proportion of terrestrial insects taken by fish caught at different times during the summer months (Table VIII). Of the aquatic food animals, the larva of *Sialis lutaria* (alder fly) was important in June samples. *Sialis* is often abundant in acid lochs where limited fish populations permit an increase in the number of invertebrate predators such as beetles (Dytiscidae), dragonfly nymphs (*Anisoptera*) and alder flies.

A scarcity of fish in acid waters may be due, at least in part, to a scarcity of food organisms. The present survey and the results of work in acid waters in central and south west Scotland (Harriman and Morrison, 1981; Harriman *et al.*, 1987) suggest that this is unlikely to be the main reason for low fish populations. There is evidence that even where aquatic food is limited, terrestrial insects are abundant. Furthermore, the results of this survey show that even in waters around pH 5 the condition of the fish generally is good.

Loch Samples — Zooplankton

The plankton fauna of the lochs generally is typical of acid waters, with a predominance of two small species, namely *Bosmina coregoni* and *Alonopsis elongata* (Almer *et al.*, 1974). Unpublished data from acid lochs in Galloway, south-west Scotland, showed similar results, with *Diaphanosoma brachyurum* Lieven present in large numbers in certain lochs. The absence from the samples of two relatively large (10 mm) summer species, *Leptodora kindti* Focke and *Bythotrephes longimanus* Leydig, probably reflects a real absence from the lochs even although these species each normally comprise less than 1% of the fauna. *Bythotrephes* in particular is often a common trout food item but it did not appear in any of the 182 trout stomachs examined. Instead, another large plankter, *Eurycercus lamellatus* Müller was found. This is a littoral species which explains why it was not always taken in an open water tow. *Polyphemus pediculus* (L.) is also normally a littoral species but the studies in Galloway lochs have shown that it also appears less commonly in open water. The scarcity of *Daphnia hyalina* Leydig, a widely distributed and abundant species, and an important trout food, is probably due to the acidity of the water. Many species of *Daphnia* appear to be sensitive to pH values below 5.5 (Almer *et al.*, 1974; Hendrey and Wright, 1976).

Littoral Benthos

The very low numbers and limited range of species collected from most lochs was probably due to the nature of the substrate which generally consisted of large stones or boulders embedded in granite grit, often with little or no plant life. The greatest range of species was collected from lochs which had littoral zones consisting of stones (3 to 20 cm across) with low growing macrophytes such as *Littorella uniflora* (L.), *Lobelia dortmanna* (L.) and *Juncus bulbosus* (L.) as in Loch Einich and Loch a' Bhanain. In addition to these, Loch Callater had larger plants such as *Myriophyllum* spp. This difference in numbers and species range between a sand or grit substrate and one where plant life and small stones are widespread

can also be demonstrated in chemically-richer lochs. In Loch Kinardochy, Perthshire (pH 7.2 to 7.7, alkalinity 12 to 25 mg l^{-1}, as $CaCO_3$) sampling the sand substrate produced 57 animals belonging to six taxa whereas in the stony substrate 261 animals belonging to nine taxa were collected (SOAFD unpublished data). The acidity of the Grampian lochs is also likely to limit species distribution. In the UK, *Gammarus* spp. are not normally found at a pH below 6.0 and mayflies of the genus *Baetis* below about 5.5. *Siphlonurus lacustris* Etn. and *Leptophlebia* spp. may be found in waters of pH 4.5 or less. The only molluscs to be found were the acid tolerant *Limnaea peregra* Müller, *Ancylus fluviatilis* Müller and *Pisidium* spp. which have also been found in Loch Dee, Galloway, where the mean pH is 5.1 (Burns *et al.*, 1984). For both molluscs and crustaceans it is possible that low calcium concentrations, often below 50 µeq l^{-1} (1 mg l^{-1}), are also a limiting factor as calcium is an essential element in the crustacean exoskeleton and the molluscan shell. Many of the taxa of the loch benthos were oligochaetes and this is no doubt a consequence of the sandy nature of the substrate with a fine overlying deposit of peat particles in some areas. If the samples of benthos collected give a true indication of the quantity of aquatic food available to the trout, it is not surprising that terrestrial insects were found in such quantity in the stomachs.

Conclusions

All the streams which were sampled could support juvenile salmonid populations, although the River Eidart requires further study. Salmon distribution is limited by impassable falls, but generally population densities of salmon and trout are comparable with those recorded elsewhere. Trout were absent from lochs of very high altitude (900 to 1,000 m) where conditions for spawning and feeding were very poor, but were present in lochs at lower altitude even when no spawning streams were available and the pH of the water was sometimes below 5.0. The streams (usually > pH 6.0) were generally less acid than the lochs (usually pH 5.0 to 6.0) but both had low alkalinities indicating a poorly buffered environment, and low levels of calcium, normally < 100 µeq l^{-1} (2 mg l^{-1}). Labile aluminium levels were also low. These conditions could explain the limited range of zooplankton fauna, which was dominated by *B. coregoni* and *A. elongata*, and benthos species, represented in only three lochs by more than 10 taxa. (Difficulties in sampling may be a factor here. The bouldery nature of the littoral zone of several of the lochs reduced the efficiency of standard sampling techniques.) Aquatic food for trout may therefore be limited but the diet is probably supplemented considerably by terrestrial insects.

The fish population in these poorly buffered waters, particularly in the lochs, could be at risk if acidification progressed further.

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